Chemical Hydride Slurry for Hydrogen Production and Storage (New FY 2004 Project)

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Objectives

- Develop a MgH_2 slurry system with a gravimetric density >11 wt% H_2
- Develop a MgH_2 slurry system with a gravimetric capacity of >1.5 kWh/kg
- Develop viable methods to recycle by-products and produce MgH_2 from Mg and H_2 to meet DOE cost targets

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Storage section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year R,D&D Plan:

- A. Cost
- B. Weight and Volume
- Q. Regeneration Processes for Irreversible Systems

Approach

Safe Hydrogen, LLC is developing a new hydrogen storage medium using chemical hydride slurry, which is made by mixing chemical hydride with mineral oil and dispersants. The oil coats the hydride particles and protects them from inadvertent contact with water while also moderating the reaction rate of the hydride with water when desired. The slurry itself will store 5 kg of hydrogen in less than 52 L of volume. The by-product of the reaction will be stored in the same container as the hydride slurry but will be separated by a baffle or barrier.

The primary purpose for developing the slurry is to create energy-dense chemical hydrides that can be transported, pumped and metered as a liquid. Additionally, the slurry storage medium enhances safety by eliminating the need to transport hydrogen gas. Hydrogen gas is produced as needed by mixing the chemical hydride slurry with water. Unlike hydrogen gas, possible slurry seepage can be identified and contained quickly.

A project focused on lithium hydride indicated that magnesium hydride slurry could provide additional safety and cost benefits. Magnesium hydride slurry reacts very slowly at room temperatures. As a result, if the slurry is spilled into a pool of water, only a few bubbles of hydrogen are produced each minute. The by-product of the reaction is quite safe (magnesium hydroxide, sometimes called “milk of magnesia,” is used as an antacid or laxative). It is also expected that magnesium hydride would cost less to manufacture than lithium hydride.

The proposed project focuses on:

1. Slurry development
2. Mixer development
3. Recycle system development

In the slurry development, Safe Hydrogen plans to develop magnesium hydride slurry as demonstrated with lithium hydride slurry. In the mixer development, Safe Hydrogen will improve the mixer design for slurries of magnesium hydride or lithium hydride. We will reduce the size, weight, and production cost of the mixing system while increasing its robustness.

The majority of the work planned for this project is development of the recycle system. The economics of the system depend on the recycle costs. By using the metal several times a year, the amount of hydrogen carried by each unit of metal is increased and the cost of hydrogen is decreased. By operating large-scale plants, we reduce the cost of the metal production. We expect recycle costs to be less than production costs from ore because the front end and back end of the recycle process are much simpler and lower cost than those of the production process.

There are two currently-used methods of reducing magnesium. The most common method electrolytically separates magnesium from magnesium chloride. The other is a metallothermic method that uses ferrosilicon as a reductant. A potentially lower cost carbothermic method was used in the 1940s and 1950s by the Permanente Metals Company. One of its intermediate products was powdered magnesium that would be particularly attractive for making magnesium hydride slurry.

A new method of producing magnesium from magnesium oxide being developed by Boston University has the potential to reduce costs and simplify the process. We intend to evaluate and compare the various methods of reducing magnesium and lithium. The evaluations will begin with process design and analyses to estimate the cost of production by each method. Experimental activities are coupled with the process analyses to provide additional process understanding of the Boston University process and new carbothermic reduction technology.